MODULE 2 LAKES

2.1

MERCURY DEPOSITION NETWORK

MERCURY DEPOSITION NETWORK

Atmospheric deposition is thought to be a significant source of mercury to Maine surface waters. In order to determine the relative significance of sources throughout Maine and the Northeast region, Maine has joined the Mercury Deposition Network (MDN). The MDN was created as an adjunct to the National Atmospheric Deposition Program (NADP), that has been monitoring the effects of atmospheric deposition of other contaminants, including acid rain, across the US for over 10 years. Maine has 4 NADP stations, one each at Bridgton, Acadia National Park (ANP), Greenville, and Caribou.

The MDN measures mercury in wet deposition on a weekly basis and provides a measurement of annual deposition at each station. All stations use similar equipment, the same protocol, and all samples will be analyzed by the same lab. There is also a Northeast regional network of MDN and other types of stations that measures wet deposition, as well as dry and gaseous mercury in some locations, in the New England states and the Canadian Maritime provinces.

One goal of MDN is to continue monitoring for at least 5 years. In Maine there are currently MDN stations at Acadia National Park (ANP, since fall 1995), Bridgton (since July 1997), Greenville (since September 1996), and Freeport (since 1998). The ANP station was supported equally by the National Park Service (NPS) and DEP through SWAT ($6000). The Greenville station was funded entirely by SWAT ($16500). The Bridgton station was funded primarily by an EPA REMAP grant, with DEP providing the station operator and mailing of the samples ($3150 SWAT). The Freeport station was supported entirely by a grant from EPA.

Annual deposition is greatest for the coastal stations, Freeport and Acacia National Park, followed by Bridgton and Greenville. Mean volume weighted concentration generally follows the same pattern. Ratios of annual deposition to mean concentration show that higher deposition along the coast is not entirely due to higher concentrations, but also due to increased precipitation.

TABLE 2.1 MERCURY IN WET DEPOSITION AT MAINE MDN STATIONS

ANNUAL DEPOSITION (ug/m2)

STATION	ID	1995	1996	1997	1998	1999	2000	2001
Bridgton	ME02			5.7e	6.9	6.9	6.9	4.8
Greenville	ME09		5.5e	5.4	6.7	6.9	5.2	4.0
Freeport	ME96				12.0e	8.4	7.9	4.9
ANP	ME98	5.2e	7.8	7.7	9.0	8.0	8.7	5.3

e= estimated, site started during year

MEAN CONCENTRATION (ng/l)

STATION	ID		1996	1997	1998	1999	2000	2001
Bridgton	ME02			8.4e	6.6	6.3	6.4	6.6
Greenville	ME09		4.0e	5.9	5.9	5.5	5.1	6.2
Freeport	ME96				7.8	7.3	6.6	6.9
ANP	ME98	5.2e	6.0	6.8	6.1	6.1	7.0	8.0

e=estimated since station began during the year

Mercury Deposition Network: a NADP Network

MDN Objectives

The objective of the MDN is to dvelop a national database of weekly concentrations of total mercury in precipitation and the easonal and annual flux of total mercury in wet deposition. The data will be used to develop information on spatial and seasonal trends in mercury deposited to surface waters, forested watersheds, and other sensitive receptors.

Analysis of precipitation samples for total- and methylmercury is performed by Frontier Geosciences, Inc., Seattle WA, USA. Frontier Geosciences provides the environmental sciences community with uncompromisingly high-quality contract research, project design and management, and analytical chemistry services concerned with the sources, fate and effects of trace metals.

The MDN began a transition network of 13 sites in 1995. Beginning in 1996, MDN became an official network in NADP with 26 sites in operation. Over 50 sites were in operation during 2000 (see site map). The MDN is anticipated to operate for a minimum of five years and will be managed at the NADP Coordination Office. The network uses standardized methods for collection and analyses. **Weekly** precipitation samples are collected in a modified Aerochem Metrics model 301 collector. The "wet-side" sampling glassware is removed from the collector every Tuesday and mailed to the **Hg Analytical Laboratory (HAL)** at Frontier Geosciences in Seattle, WA for analysis by cold vapor atomic fluorescence. The MDN provides data for total mercury, but also includes methylmercury if desired by a site sponsor. Data are available via this Web page for the transition network (1995) and for 1996 through the second quarter of 2000.

The following journal articles and presentations describe the network design, including the sampling and analytical protocols, used in the MDN:

Lindberg, S. and Vermette, S. 1995. Workshop on Sampling Mercury in Precipitation for the National Atmospheric Deposition Program. Atmospheric Environment. 29, 1219-1220.

Vermette, S., Lindberg, S., and Bloom, N. 1995. Field Tests for a Regional Mercury Deposition Network - Sampling Design and Preliminary Test Results. Atmospheric Environment. 29, 1247-1251.

Welker, M. and Vermette, S.J., 1996. Mercury Deposition Network: QA/QC Protocols. Paper 96-RP129.01, Proceedings of the 89th Annual Meeting of the Air and Waste Management Association, A&WMA, Pittsburgh, PA.

Sweet, C.W. and Prestbo, E. 1999. Wet Deposition of Mercury in the U.S. and Canada. Presented at "Mercury in the Environment Specialty Conference", September 15-17, 1999, Minneapolis, MN. Proceedings published by Air and Waste Management Association, Pittsburgh, PA.

(Available from NADP Program Office)

Image credit: Mackerel On Mercury by Scot F. Hacker , 1995.

MDN DATA FIELDS

SITE CODE: 2-letter state or province designator plus SAROAD county code (US) or sequential number (Canada).

START DATE: (mm/dd/yyyy)

END DATE: (mm/dd/yyyy)

SUBPPT: Rain Gauge (RG) precipitation amount in mm if available, otherwise precipitation amount in mm is calculated from the net rain volume caught in the sample bottle.

PPT: Precipitation amount in mm from the rain gauge (RG), if blank, no RG data.

HG CONC: total mercury concentration reported by the lab in ng/L.

DEPOSITION: product of SUBPPT and HG CONC, units are ng/m2.

Quality rating (QR) CODE: A = fully qualified with no problems

B = valid data with minor problems, used for summary statistics

C = invalid data, not used for summary statistics

BLANK= no sample submitted for this time period

SAMPLE TYPE:

W = wet sample, measurable precipitation (> or = 0.03 in.) on the rain gauge (RG) or net bottle catch (BC) = or > 10.0 mL if RG data are missing. Concentration and deposition data are reported unless the QR Code = C.

D = dry sample, no indication of sampler openings on the RG or net BC < 1.5 mL if RG event recorder data are missing. No concentration data are reported. ppt, subppt, and deposition are set to zero.

T = trace sample, RG shows openings or a trace precipitation amount (<0.03 inches). If the RG data are missing, a net BC between 1.5 and 10.0 mL (inclusive) will be coded as a T sample type. Concentration data may or may not be reported depending whether the BC is 1.5 mL or higher. If BC = 1.5 mL or higher, then ppt is blank , Subppt = BC, and deposition is based on the BC. If BC < 1.5 mL, then ppt subppt and deposition are all set to zero.

Q = sampler was used for a Quality assurance (QA) sample, no ambient sample submitted. No concentration values are reported (QA values will be published in the QA report). Deposition is only reported where the value is zero (D or T samples with no measurable precipitation).

NOTES:	QR CODE	Valid for Summaries (Y/N)
s = short sample time (< 6days)	B	Y
e = extended sample time (> 8days)	B	Y
d = debris present (previously x)	B	Y

m = missing information (previously, r, no event recorder, and p, missing RG precipitation record)	B	Y
z = site operations problems	B	Y
h = sample handling problems (z and h include equipment and handling problems that don’t seriously compromise the sample)	B	Y
i = low volume sample (1.49mL < net BC < 10.00mL) (Hg conc. Data are reported but they are less certain than those for samples with a net BC of at least 10 mL)	B	Y
b = bulk sample (wet side open the whole time)	C	N
v = RG indicates precipitation occurred but BC < 1 mL or < 10% of indicated RG precipitation amount.	C	N
u = undefined sample (wet side open during dry periods)	C	N
f = serious problems in field operations that compromise sample integrity.	C	N
l = laboratory error	C	N
c = sample compromised due to contamination	C	N
p = no ppt data from either RG or BC	C	N
n = no sample submitted	--	N

Calculation of Deposition:

1. If a valid precipitation amount can be read from the rain gauge chart (RG >= 0.03 inches), the sample type is set to “W” (wet); and the value from the RG chart is used to calculate deposition (RG amount in mm times Hg concentration in ng/mL). If the RG chart event recorder shows no sampler openings, sample type is set to “D” (dry) and precipitation amount and deposition are set to 0.

2. If the precipitation amount from the RG chart is not available, the net bottle catch (BC) will be used to calculate deposition as long as BC > 1.49mL. If the BC < 1.5 mL, the precipitation amount will be set to 0 and the sample type set to “D” (dry). If the BC is between 1.5 and 10.0 mL, the sample type will be set to “T” (trace) and the BC used to calculate deposition. These samples are also coded with an “i” in the Notes field and downgraded to a “B” Quality Rating to indicate uncertainty due to low volume. If the BC

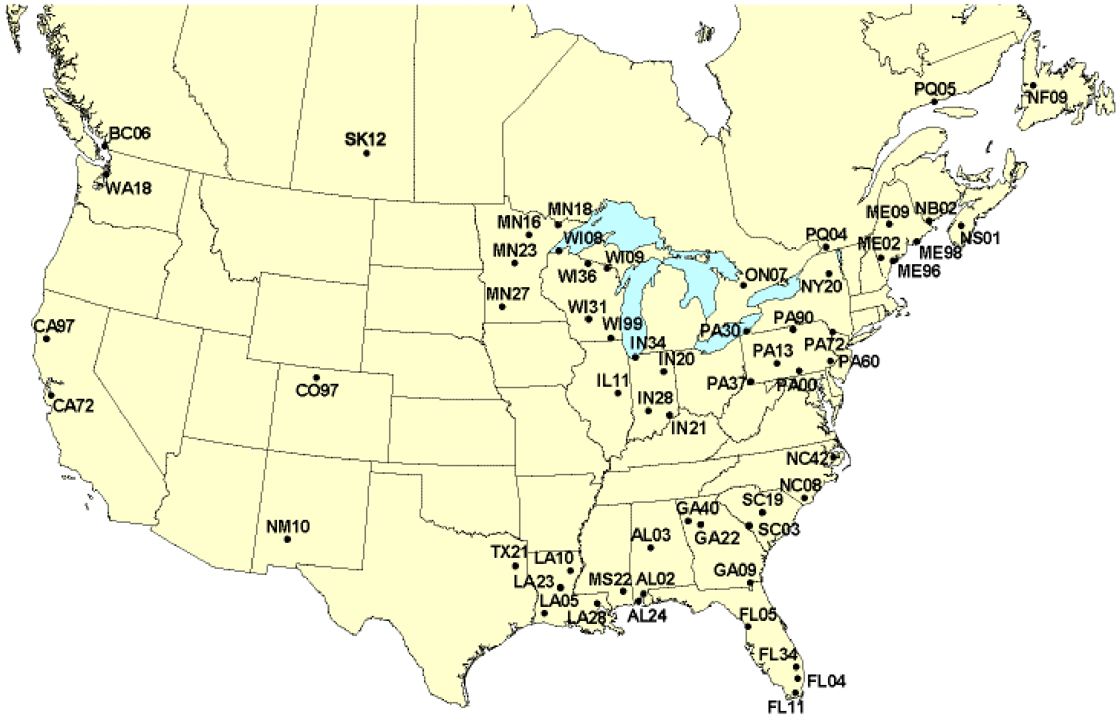
is > 10 mL, the sample type will be set to “W” (wet) and the BC will be used to calculate deposition.

3. If the RG indicates sampler openings, but the precipitation amount can’t be determined accurately from the RG chart (RG < 0.03 inches) the sample type will be coded “T” (trace) and the BC will be used to calculate deposition as long as the BC is >= 1.5mL. If the BC is < 10mL, samples will be coded for low volume as in 2. If the BC is < 1.5mL, no concentration will be reported and the ppt, subppt, and deposition will be set to 0.

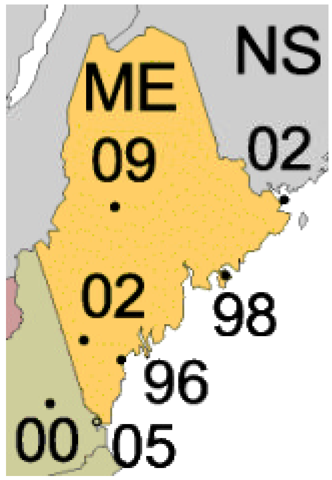
4. In cases where there is a valid precipitation amount from either RG or BC but invalid or missing concentration data, seasonal or annual summary deposition values will be calculated using the site-specific, seasonal, volume-weighted average concentration. This deposition value will not be displayed for individual weeks in the WEB database, but it will be used only for the calculation seasonal and annual average concentrations and deposition amounts on maps and other summary products.

MDN STATIONS

National Atmospheric Deposition Program
Mercury Deposition Network



Mercury Deposition Network   Maine stations



Site ID	Site Name	Start Date	End Date	Elevation (meters)
Active Sites				
ME02	Bridgton	06/04/1997		222
ME09	Greenville Station	09/03/1996		322
ME96	Freeport	01/01/1998		15
ME98	Acadia National Park - McFarland Hill	09/26/1995		129
Inactive Sites				

BRIDGTON ME02

Site	Date On	Date Off	Subppt mm	Pptrec mm	HgConc ng/L	HgDep ng/m²	QR	Sample Type	Notes
ME02	12/26/2000	1/2/2001	0	0	4.5	0	B	W	m
ME02	1/2/2001	1/9/2001	8.6	8.6	1.4	12	B	W	m
ME02	1/9/2001	1/16/2001	5.8	5.8	e3.8	22	C	W	mhf
ME02	1/16/2001	1/23/2001	1.8	1.8	6.1	10.9	B	W	mi
ME02	1/23/2001	1/30/2001	0	0	--	0	A	D	
ME02	1/30/2001	2/6/2001	39.7	39.7	2.1	82.2	B	W	mh
ME02	2/6/2001	2/13/2001	8.3	8.3	8.3	68.7	B	W	m
ME02	2/13/2001	2/20/2001	2.2	2.2	11.4	24.7	B	W	dmz
ME02	2/20/2001	2/27/2001	21	21	6.2	130.1	B	W	dm
ME02	2/27/2001	3/6/2001	17.5	17.5	e4.6	80.5	C	W	dmhf
ME02	3/6/2001	3/13/2001	15.2	15.2	3	45	B	W	dmz
ME02	3/13/2001	3/20/2001	2.5	2.5	3.8	9.8	B	W	d
ME02	3/20/2001	3/27/2001	45.5	45.5	0.9	41.5	B	W	dmz
ME02	3/27/2001	4/3/2001	29.5	29.5	3.1	91.1	B	W	mh
ME02	4/3/2001	4/10/2001	7.5	7.5	10.7	80.1	B	W	m
ME02	4/10/2001	4/17/2001	20.6	20.6	6.9	142.5	B	W	dm
ME02	4/17/2001	4/24/2001	0.9	0.9	17.4	15.4	B	W	dmi
ME02	4/24/2001	5/1/2001	0	0	--	0	B	T	d
ME02	5/1/2001	5/8/2001	1	1	17.6	16.8	B	W	di
ME02	5/8/2001	5/15/2001	12.2	12.2	25.2	307.3	B	W	d
ME02	5/15/2001	5/22/2001	1	1	11.3	11.5	A	W	
ME02	5/22/2001	5/29/2001	26.7	26.7	14.2	377.5	B	W	d
ME02	5/29/2001	6/5/2001	68.6	68.6	7.2	492.9	B	W	d
ME02	6/5/2001	6/12/2001	6.9	6.9	12.7	87	B	W	d
ME02	6/12/2001	6/19/2001	10.2	10.2	20	202.7	B	W	d
ME02	6/19/2001	6/26/2001	9.1	9.1	8.2	74.2	B	W	d
ME02	6/26/2001	7/3/2001	10.2	10.2	12.9	131.6	B	W	d
ME02	7/3/2001	7/10/2001	22.1	22.1	11.5	254.2	B	W	d
ME02	7/10/2001	7/17/2001	23.1	23.1	9.6	221.8	B	W	d
ME02	7/17/2001	7/24/2001	1	1	e7.0	7	C	W	dv
ME02	7/24/2001	7/31/2001	8.5	8.5	4.3	36.6	B	W	d
ME02	7/31/2001	8/7/2001	2.3	2.3	28	64.4	A	W	
ME02	8/7/2001	8/14/2001	7.1	7.1	12	85.2	B	W	dz
ME02	8/14/2001	8/21/2001	2	2	11	22	B	W	d
ME02	8/21/2001	8/28/2001	0	0	0	0	A	T	
ME02	8/28/2001	9/4/2001	22.9	22.9	9.1	208.4	B	W	d
ME02	9/4/2001	9/11/2001	8	8	8.6	68.8	B	W	d
ME02	9/11/2001	9/18/2001	0	0	0	0	A	T	
ME02	9/18/2001	9/25/2001	20.6	20.6	10.2	210.1	A	W	
ME02	9/25/2001	10/2/2001	32	32	5	160	B	W	dh
ME02	10/2/2001	10/9/2001	2.2	2.2	6	13.2	A	W	
ME02	10/9/2001	########	12.4	12.4	6.1	75.6	B	W	d
ME02	10/16/2001	########	16.4	16.4	7.9	129.6	B	W	dh
ME02	10/23/2001	########	11.9	11.9	10.7	127.3	B	W	d
ME02	10/30/2001	11/6/2001	43.9	43.9	1.6	70.2	B	W	d
ME02	11/6/2001	########	2	2	17.1	34.2	B	W	d
ME02	11/13/2001	########	2.3	2.3	10.1	23.2	B	W	d
ME02	11/20/2001	########	13.5	13.5	4.7	63.4	B	W	d
ME02	11/27/2001	12/4/2001	28.4	28.4	4.5	127.8	A	W	
ME02	12/4/2001	########	4.7	4.7	9.7	45.6	B	W	d
ME02	12/11/2001	########	28.8	28.8	2.1	60.5	B	W	d
ME02	12/18/2001	########	10.3	10.3	2.1	21.6	B	W	d

GREENVILLE MEO9

Site	Date On	Date Off	Subppt mm	Pptrec mm	HgConc ng/L	HgDep ng/m²	QR	Sample Type	Notes
ME09	12/26/2000	1/2/2001	19.3	19.3	2.1	41	A	W	
ME09	1/2/2001	1/9/2001	2.8	2.8	4.7	13.1	A	W	
ME09	1/9/2001	1/16/2001	3	3	4	12.1	B	W	zi
ME09	1/16/2001	1/23/2001	1.8	1.8	4.5	8	A	W	
ME09	1/23/2001	1/30/2001	0	0	--	0	A	T	
ME09	1/30/2001	2/6/2001	47	47	2.7	125.8	B	W	dzh
ME09	2/6/2001	2/13/2001	8.3	8.3	7	57.8	B	W	zh
ME09	2/13/2001	2/20/2001	4.6	4.6	4.6	21.1	B	W	dz
ME09	2/20/2001	2/27/2001	10.7	10.7	25.6	272.9	B	W	d
ME09	2/27/2001	3/6/2001	0	0	--	0	A	D	
ME09	3/6/2001	3/13/2001	2.8	--	4	11.2	B	W	m
ME09	3/13/2001	3/20/2001	14.5	14.5	2.1	30.2	B	W	dz
ME09	3/20/2001	3/27/2001	23.7	23.7	1.7	39.5	B	W	d
ME09	3/27/2001	4/3/2001	22	22	8.4	184.8	B	W	d
ME09	4/3/2001	4/10/2001	0.5	0.5	--	0	A	T	
ME09	4/10/2001	4/17/2001	6.1	6.1	9.1	55.2	B	W	d
ME09	4/17/2001	4/24/2001	0	0	--	0	B	T	z
ME09	4/24/2001	5/1/2001	4.2	--	11.5	48.3	B	W	dmp
ME09	5/1/2001	5/8/2001	2.7	2.7	13.3	35.6	B	W	dm
ME09	5/8/2001	5/15/2001	7.7	7.7	12.1	93.5	B	W	dmz
ME09	5/15/2001	5/22/2001	8.9	8.9	7.5	66.9	B	W	dm
ME09	5/22/2001	5/29/2001	19.1	19.1	4.2	80.8	B	W	dmh
ME09	5/29/2001	6/5/2001	38.1	38.1	8.5	324.6	B	W	dh
ME09	6/5/2001	6/12/2001	0.4	--	27.3	10.1	B	T	i
ME09	6/12/2001	6/19/2001	25	25	3.8	94.1	B	W	dzh
ME09	6/19/2001	6/26/2001	25.3	25.3	2.1	51.9	B	W	dh
ME09	6/26/2001	7/3/2001	10.3	10.3	16.4	168.9	B	W	d
ME09	7/3/2001	7/10/2001	37.1	37.1	6.3	233.7	B	W	dh
ME09	7/10/2001	7/17/2001	19.3	19.3	8.6	166	B	W	d
ME09	7/17/2001	7/24/2001	3.9	3.9	11.6	45.2	B	W	d
ME09	7/24/2001	7/31/2001	1.3	1.3	18.2	23.7	B	W	d
ME09	8/7/2001	8/14/2001	0	0	0	0	B	T	d
ME09	8/14/2001	8/21/2001	9.4	9.4	9.8	92.1	B	W	d
ME09	8/21/2001	8/28/2001	21.6	21.6	6.7	144.7	B	W	dh
ME09	8/28/2001	9/4/2001	20.8	20.8	10.7	222.6	B	W	d
ME09	9/4/2001	9/11/2001	29	29	3.9	113.1	B	W	dz
ME09	9/18/2001	9/25/2001	33	33	6	198	B	W	d
ME09	9/25/2001	10/2/2001	19.6	19.6	7.2	141.1	B	W	dh
ME09	10/2/2001	10/9/2001	6.6	6.6	3.8	25.1	B	W	dh
ME09	10/9/2001	10/16/2001	2.8	2.8	3.1	8.7	B	W	d
ME09	10/16/2001	10/23/2001	21.1	21.1	7.2	151.9	B	W	d
ME09	10/23/2001	10/30/2001	15.7	15.7	10.5	164.8	B	W	d
ME09	10/30/2001	11/6/2001	2.8	2.8	2.5	7	B	W	dz
ME09	11/6/2001	11/13/2001	10.2	10.2	e4.5	45.9	C	W	dzl
ME09	11/13/2001	11/20/2001	2.3	2.3	6.5	15	B	W	dh
ME09	11/20/2001	11/27/2001	12.2	12.2	2.9	35.4	B	W	dzh
ME09	11/27/2001	12/4/2001	19.6	19.6	3.9	76.4	B	W	dzh
ME09	12/4/2001	12/11/2001	5.5	5.5	10.4	57.2	B	W	dz
ME09	12/11/2001	12/18/2001	20.3	20.3	2.4	48.7	B	W	d
ME09	12/18/2001	12/24/2001	20.4	20.4	e2.4	48.7	C	W	dv

FREEPORT ME96

Site	Date On	Date Off	Subppt mm	Pptrec mm	HgConc ng/L	HgDep ng/m²	QR	Sample Type	Notes
ME96	12/26/2000	1/2/2001	16	16	3.1	49.4	B	W	d
ME96	1/2/2001	1/9/2001	6.1	6.1	4	24.4	A	W	
ME96	1/9/2001	1/16/2001	1.8	1.8	6.5	11.5	A	W	
ME96	1/16/2001	1/23/2001	5.3	5.3	7.5	40.2	A	W	
ME96	1/23/2001	1/30/2001	0	0	--	0	B	D	h
ME96	1/30/2001	2/6/2001	31	31	4.5	138.1	B	W	d
ME96	2/6/2001	2/13/2001	7.4	7.4	4.4	32.7	B	W	d
ME96	2/13/2001	2/20/2001	5.8	5.8	4.1	23.8	B	W	d
ME96	2/20/2001	2/27/2001	24.6	24.6	4.2	104.1	B	W	d
ME96	2/27/2001	3/7/2001	16.5	16.5	4.7	77.2	A	W	
ME96	3/7/2001	3/13/2001	6.4	6.4	3.7	23.6	B	W	dz
ME96	3/13/2001	3/20/2001	7.4	--	5.6	41	B	W	m
ME96	3/20/2001	3/27/2001	112.2	112.2	1.8	201.2	B	W	d
ME96	3/27/2001	4/3/2001	36.7	36.7	1.6	58	B	W	d
ME96	4/3/2001	4/10/2001	5.1	5.1	e3.7	18.9	C	W	dzvf
ME96	4/10/2001	4/17/2001	33	33	5.8	190.1	B	W	d
ME96	4/17/2001	4/24/2001	1	1	26.3	26.7	B	W	di
ME96	4/24/2001	5/1/2001	0.8	0.8	54.1	41.2	B	W	zi
ME96	5/1/2001	5/8/2001	5.1	5.1	13.1	66.6	B	W	dh
ME96	5/8/2001	5/15/2001	1.3	1.3	19.8	25.2	B	W	di
ME96	6/5/2001	6/12/2001	36.6	36.6	12.2	446.7	B	W	d
ME96	6/12/2001	6/19/2001	21.6	21.6	28.6	617.5	B	W	dh
ME96	6/19/2001	6/26/2001	0.8	0.8	16.3	12.4	B	W	d
ME96	6/26/2001	7/3/2001	19.3	19.3	19.8	382.1	B	W	h
ME96	7/3/2001	7/10/2001	3	3	19.7	59.1	B	W	d
ME96	7/10/2001	7/17/2001	22.4	22.4	11.8	264.3	A	W	
ME96	7/17/2001	7/24/2001	0.9	0.9	11.8	10.6	B	W	i
ME96	7/24/2001	7/31/2001	8.4	8.4	5.3	44.5	B	W	d
ME96	7/31/2001	8/7/2001	0	0.5	0	0	B	T	d
ME96	8/7/2001	8/14/2001	0.3	0	162.2	48.7	B	T	mi
ME96	8/14/2001	8/21/2001	3.3	3.3	14.2	46.9	A	W	
ME96	8/21/2001	8/28/2001	0	0	0	0	B	D	d
ME96	8/28/2001	9/4/2001	19.3	19.3	8	154.4	B	W	d
ME96	9/4/2001	9/11/2001	6.1	6.1	12.2	74.4	B	W	d
ME96	9/11/2001	9/18/2001	0.3	--	14	4.2	B	T	dmi
ME96	9/18/2001	9/25/2001	40.1	40.1	6.8	272.7	B	W	d
ME96	9/25/2001	10/2/2001	31.5	31.5	7.6	239.4	B	W	d
ME96	10/2/2001	10/9/2001	3.8	3.8	5.3	20.1	B	W	dz
ME96	10/9/2001	10/16/2001	10.9	10.9	4.6	50.1	B	W	d
ME96	10/16/2001	10/23/2001	20.3	20.3	8	162.4	B	W	dz
ME96	10/23/2001	10/30/2001	3.8	3.8	10.8	41	B	W	dzh
ME96	10/30/2001	11/6/2001	35.8	35.8	4.6	164.7	B	W	dh
ME96	11/6/2001	11/13/2001	3.8	3.8	14.3	54.3	B	W	dh
ME96	11/13/2001	11/20/2001	1.3	1.3	10.9	14.2	B	W	di
ME96	11/20/2001	11/27/2001	13.6	13.6	4.7	63.9	B	W	d
ME96	11/27/2001	12/4/2001	18.5	18.5	8.7	161	B	W	d
ME96	12/4/2001	12/11/2001	4.8	4.8	5.7	27.4	B	W	dh
ME96	12/11/2001	12/18/2001	25.1	25.1	3.6	90.4	B	W	d
ME96	12/18/2001	12/26/2001	26.7	26.7	4.3	114.8	B	W	d

ACADIA NATIONAL PARK ME98

Site	Date On	Date Off	Subppt mm	Pptrec mm	HgConc ng/L	HgDep ng/m²	QR	Sample Type	Notes
ME98	12/26/2000	1/2/2001	21.3	21.3	2.3	49.4	B	W	mh
ME98	1/2/2001	1/9/2001	9.7	9.7	e3.0	29.1	C	W	hf
ME98	1/9/2001	1/16/2001	3.3	3.3	e3.0	9.9	C	W	vf
ME98	1/16/2001	1/23/2001	6.1	6.1	e3.0	18.3	C	W	hvf
ME98	1/23/2001	1/30/2001	1.3	1.3	e3.0	3.9	C	W	hvf
ME98	1/30/2001	2/7/2001	27.2	27.2	3.7	99.9	B	W	dh
ME98	2/7/2001	2/13/2001	8.9	8.9	e3.6	32	C	W	f
ME98	2/13/2001	2/20/2001	24.1	24.1	3.5	83.8	A	W	
ME98	2/20/2001	2/27/2001	14.2	14.2	15.7	223.3	B	W	dh
ME98	2/27/2001	3/7/2001	3	3	e9.6	28.8	C	W	v
ME98	3/7/2001	3/13/2001	10.9	10.9	3.5	37.7	B	W	d
ME98	3/13/2001	3/20/2001	12.7	12.7	5.3	67.1	B	W	dz
ME98	3/20/2001	3/27/2001	36.3	36.3	4.1	149.8	B	W	dzh
ME98	3/27/2001	4/3/2001	23.4	23.4	e6.9	161.5	C	W	hf
ME98	4/3/2001	4/10/2001	3.2	3.2	9.7	30.8	A	W	
ME98	4/10/2001	4/17/2001	25.4	25.4	6.7	171	B	W	dh
ME98	4/17/2001	4/24/2001	16	16	3.8	61.1	B	W	d
ME98	4/24/2001	5/1/2001	0.5	--	32.8	15.4	B	T	i
ME98	5/1/2001	5/8/2001	3.4	3.4	13.3	45.7	A	W	
ME98	5/8/2001	5/15/2001	2.8	2.8	16.1	45	A	W	
ME98	5/15/2001	5/22/2001	20.8	20.8	7.6	158.3	A	W	
ME98	5/22/2001	5/29/2001	18.8	18.8	6.5	122.7	B	W	dh
ME98	5/29/2001	6/5/2001	47.8	47.8	11.1	529.3	B	W	h
ME98	6/5/2001	6/12/2001	10.7	10.7	22.3	237.4	B	W	d
ME98	6/12/2001	6/19/2001	27.9	27.9	8.9	248.1	B	W	dh
ME98	6/19/2001	6/26/2001	10.9	10.9	7.6	83.2	B	W	d
ME98	6/26/2001	7/3/2001	2.8	2.8	102.4	286.7	B	W	dmi
ME98	7/3/2001	7/10/2001	7.6	7.6	11.7	88.9	B	W	h
ME98	7/10/2001	7/17/2001	2.5	2.5	14.8	37	B	W	d
ME98	7/17/2001	7/24/2001	1.8	1.8	11.2	20.2	B	W	d
ME98	7/24/2001	7/31/2001	5	5	11.5	57.5	B	W	dh
ME98	7/31/2001	8/7/2001	0	0	0	0	A	T	
ME98	8/7/2001	8/14/2001	14.2	14.2	14.5	205.9	B	W	dh
ME98	8/14/2001	8/21/2001	3.8	3.8	16.5	62.7	B	W	d
ME98	8/21/2001	8/28/2001	0	0	0	0	B	T	d
ME98	8/28/2001	9/4/2001	11.7	11.7	10.5	122.8	B	W	dh
ME98	9/4/2001	9/11/2001	2	2	14	28	B	W	d
ME98	9/18/2001	9/25/2001	12.2	12.2	12.2	148.8	B	W	dh
ME98	9/25/2001	10/2/2001	34	34	8.7	295.8	B	W	d
ME98	10/2/2001	10/9/2001	2.5	2.5	7.2	18	B	W	d
ME98	10/9/2001	10/16/2001	4.4	4.4	4.9	21.6	B	W	dh
ME98	10/16/2001	10/23/2001	31.6	31.6	4.5	142.2	B	W	dh
ME98	10/23/2001	10/30/2001	5.3	5.3	10.7	56.7	B	W	dh
ME98	10/30/2001	11/6/2001	23.6	23.6	2.2	51.9	B	W	d
ME98	11/6/2001	11/13/2001	6.6	6.6	11.9	78.5	B	W	dh
ME98	11/13/2001	11/20/2001	0	0	0	0	A	T	
ME98	11/20/2001	11/27/2001	12.7	12.7	6.4	81.3	B	W	dzh
ME98	11/27/2001	12/4/2001	15.2	15.2	5.3	80.6	B	W	d
ME98	12/4/2001	12/11/2001	4.2	4.2	2.7	11.3	B	W	dh
ME98	12/11/2001	12/18/2001	24.3	24.3	2.9	70.5	B	W	d
ME98	12/18/2001	12/26/2001	46	46	5	230	B	W	d

2.2

FISH CONSUMPTION ADVISORIES

SALMONIDS

NORTHERN PIKE

CHAIN PICKEREL

DDT

FISH CONSUMPTION ADVISORIES

General Statewide -Lakes -DEP

We had hoped we could identify an indicator fish species and avoid the need to test multiple species. However, our review of the data from the 'Indicator Species Study' does not appear to support this approach. The mercury levels for the species sampled does not seem consistent enough to identify a reliable predictor fish species, though this conclusion is somewhat compromised by the small number of lakes sampled.

Therefore, we are back to looking at obtaining data at the individual species level. Collapsing data into cold water versus warm water fish species is problematic because lake trout and brown trout have mercury levels more similar to warm water fish species than other cold water species, such as brook trout or landlocked salmon. Another important determinant of data needs is our desire to estimate a high percentile lake average fish-mercury concentration rather than the statewide mean. Anglers do not necessarily fish lakes randomly or fish a large number of water bodies (if they did, the mean would be the appropriate statistic). Rather, they may have one or just a few lakes or ponds they primarily fish (especially for those people living on a lake). Consequently, we believe we need to evaluate the likelihood that individuals may routinely consume fish from a high-end lake. To do this, we need sufficient data to estimate the statewide distribution for fish species routinely consumed and to estimate high percentile lakes (e.g., 75th to 95th percentile lake). This means data from the same distribution from at least 30 lakes for each of several species.

.

Cold-water fish

In 2000 we focused on lake trout to augment the REMAP data. The Maine Department of Inland Fisheries and Wildlife collected samples from 11 lakes for mercury analysis, but the data exhibited a different distribution than did the REMAP data. Therefore, more data were needed for lake trout as well as brown trout, landlocked salmon, splake, cusk, and whitefish. We asked DIFW to collect a sample of at least 5 fish of any of these species encountered as part of their regular investigations of lakes and ponds this summer. DIFW was able to collect 23 samples from 18 lakes and ponds (Table 2.2.1). All but one sample of brook trout and one sample of splake exceeded the Maine Bureau of Health's Fish Tissue Action Level for mercury (FTAL=0.20 ppm). Although there was considerable variation in concentrations among lakes, concentrations appeared to be highest in lake trout, followed by splake, brown trout and landlocked salmon, and brook trout in decreasing amounts, but no statistical comparisons were made. More samples of each species are needed for the Bureau of Health assessment.

Northern Pike. Northern pike are highly piscivorous fish and would be expected to have higher mercury concentrations than even pickerel,which are smaller. In 2000 we were able to capture pike from only Great Pond in Belgrade and Sabattus Pond in Sabattus. Concentrations were greatly different, being much higher in Great Pond and surprisingly low in Sabattus, even though those fish were smaller. Collection of pike from Sabattus Pond was repeated in 2001. The concentration of mercury was slightly higher than in 2000 (0.06 ppm) which may be the result of larger fish in 2001 (Table 2.2.1).. Once again concentrations were lower than those from Great Pond in 2001 (0.45 ppm) which were larger than these pike from Sabattus Pond.

Table 2.2.1. MERCURY CONCENTRATIONS IN FISH FROM MAINE LAKES 2001

SUMMARY

WATER	MIDAS NO.	TOWN	SPECIES CODE	HG mg/l	N
Big Indian P	2866	T07 R12 WELS	BKT	0.27	5
Sandy River Pond	3566	Sandy River Plt	BKT	0.36	5
Tufts Pond	0028	Kingfield	BKT	0.09	5
Webster Lake	2718	T06 R10 WELS	BKT	0.21	5
Upper Shin Pond	2202	Mt Chase	BKT	0.21	1
MEAN				**0.22**	
Alford Lake	4798	Hope	BNT	0.40	5
Biscay Pond	5710	Damariscotta	BNT	0.28	5
MEAN				**0.34**	
Big Indian Pond	2866	T07 R12 WELS	LKT	0.45	5
Chamberlain Lake	2882	T07 R13 WELS	LKT	0.86	5
Cliff Lake	2780	T09 R12 WELS	LKT	0.32	5
First Roach Pond	0436	Frenchtown twp	LKT	0.40	5
Millinocket Lake	2020	T01 R08 WELS	LKT	0.56	5
Monson Pond	0380	Monson	LKT	0.22	5
Webster Lake	2718	T06 R10 WELS	LKT	0.64	5
MEAN				**0.49**	
Cross Lake	1674	T17 R05 WELS	LLS	0.22	5
Moosehead Lake	0390	Greenville	LLS	0.27	5
Upper Shin Pond	2202	Mt Chase	LLS	0.52	2
MEAN				**0.34**	
Biscay Pond	5710	Damariscotta	SPK	0.39	5
Bradbury Pond	9763	New Limerick	SPK	0.52	1
Cochrane Pond	1744	New Limerick	SPK	0.14	4
Minnehonk Lake	5812	Mt Vernon	SPK	0.27	5
Spectacle Pond	5410	Vassalboro	SPK	0.40	5
Tufts Pond	0028	Kingfield	SPK	0.44	5
MEAN				**0.36**	
Sabattus Pond	3796	Sabattus	PKE	**0.14**	5
Androscoggin Lake	3836	Wayne	PKL	0.71	5
Branch Pond	5754	China	PKL	0.39	5
China Lake	5448	China	PKL	0.62	5
Givens Pond	5450	Whitefield	PKL	0.34	5
MEAN				**0.52**	

raw data

WATER	DATE	LENGTH	WEIGHT	HG mg/l
Big Indian Pond				
#2866-BKT-1	8/22/2001	420	890	0.21
#2866-BKT-2	8/22/2001	415	840	0.31
#2866-BKT-3	8/22/2001	368	540	0.24
#2866-BKT-4	8/22/2001	378	640	0.20
#2866-BKT-5	8/22/2001	375	520	0.34
#2866-BKT-6	8/22/2001	378	700	0.32
Sandy River Pond				
#3566-BKT-1	7/10/2001	362	630	0.40
#3566-BKT-2	7/10/2001	346	490	0.42
#3566-BKT-3	7/10/2001	309	305	0.36
#3566-BKT-4	7/10/2001	318	415	0.24
#3566-BKT-5	7/10/2001	293	275	0.39
Tufts Pond				
#28-BKT-1	6/28/2001	300	250	0.05
#28-BKT-2	6/28/2001	279	220	0.08
#28-BKT-3	6/28/2001	292	245	0.18
#28-BKT-4	6/28/2001	300	275	0.07
#28-BKT-5	6/28/2001	290	285	0.10
Webster Lake				
LK2718-BKT-1	6/22/2001	405	700	0.34
LK2718-BKT-2	6/22/2001	367	470	0.28
LK2718-BKT-3	6/22/2001	225	130	0.08
LK2718-BKT-4	6/22/2001	235	145	0.24
LK2718-BKT-5	6/22/2001	337	380	0.12
Upper Shin Pond				
USP-BKT-1	7/11/2001	296	320	0.21
Alford Lake				
#4798-BNT-1	8/3/2001	445	830	0.50
#4798-BNT-2	8/3/2001	421	610	0.18
#4798-BNT-3	8/3/2001	449	860	0.36
#4798-BNT-4	8/3/2001	411	650	0.32
#4798-BNT-5	8/3/2001	460	1050	0.66

WATER	DATE	LENGTH	WEIGHT	HG mg/l
Biscay Pond				
#5710-BNT-1	7/27/2001	361	475	0.09
#5710-BNT-2	7/27/2001	435	775	0.26
#5710-BNT-3	7/27/2001	396	575	0.29
#5710-BNT-4	7/27/2001	436	950	0.26
#5710-BNT-5	7/27/2001	476	1125	0.50
Big Indian Pond				
#2866-LKT-1	8/22/2001	470	1060	0.29
#2866-LKT-2	8/22/2001	610	2500	0.45
#2866-LKT-3	8/22/2001	525	1480	0.26
#2866-LKT-4	8/22/2001	618	2550	0.54
#2866-LKT-5	8/22/2001	705	3700	0.71
Chamberlain Lake				
#2882-LKT-1	10/10/2001	600	1980	1.50
#2882-LKT-2	10/11/2001	607	1830	1.04
#2882-LKT-3	10/12/2001	528	1380	0.50
#2882-LKT-4	10/12/2001	589	720	0.69
#2882-LKT-5	10/12/2001	552	1520	0.55
Cliff Lake				
#2780-LKT-1	FALL 2001	508	1240	0.31
#2780-LKT-2	FALL 2001	545	1410	0.42
#2780-LKT-3	FALL 2001	559	1850	0.35
#2780-LKT-4	FALL 2001	400	540	0.20
First Roach Pond				
#0436-LKT-1	07/17/01	432	630	0.39
#0436-LKT-2	07/17/01	427	620	0.41
#0436-LKT-3	07/17/01	449	570	0.30
#0436-LKT-4	07/17/01	472	740	0.45
#0436-LKT-5	07/17/01	475	830	0.47
Millinocket Lake				
LK2020-LKT-1	7/12/2001	380	500	0.40
LK2020-LKT-2	7/12/2001	589	2100	0.90
LK2020-LKT-3	7/12/2001	405	600	0.45
LK2020-LKT-4	7/12/2001	456	1000	0.58
LK2020-LKT-5	7/12/2001	476	1050	0.47

WATER	DATE	LENGTH	WEIGHT	HG mg/l
Monson Pond				
MPM-LKT-1	7/5/2001	486	840	0.55
MPM-LKT-2	7/5/2001	480	830	0.25
MPM-LKT-3	7/5/2001	415	590	0.11
MPM-LKT-4	7/5/2001	399	460	0.09
MPM-LKT-5	7/5/2001	443	670	0.09
Webster Lake				
LK2718-LKT-1	6/22/2001	477	930	0.51
LK2718-LKT-2	6/22/2001	565	1580	0.66
LK2718-LKT-3	6/22/2001	508	1160	0.61
LK2718-LKT-4	6/22/2001	552	1200	0.78
LK2718-LKT-5	6/22/2001	550	1420	0.63
Cross Lake				
CRL-LLS-1	6/26/2001	470	1040	0.22
CRL-LLS-2	6/26/2001	430	735	0.24
CRL-LLS-3	6/26/2001	387	495	0.13
CRL-LLS-4	6/26/2001	447	710	0.21
CRL-LLS-5	6/26/2001	512	1070	0.29
Moosehead Lake				
LK0390-LLS-1	7/20/2001	377	440	0.28
LK0390-LLS-2	7/20/2001	363	450	0.12
LK0390-LLS-3	7/20/2001	435	820	0.30
LK0390-LLS-4	7/20/2001	430	720	0.32
LK0390-LLS-5	7/20/2001	386	520	0.33
Upper Shin Pond				
USP-LLS-1	7/11/2001	470	1110	0.75
USP-LLS-2	7/11/2001	393	540	0.30
Biscay Pond				
#5710-SPK-1	7/27/2001	325	275	0.46
#5710-SPK-2	7/27/2001	400	475	0.41
#5710-SPK-3	7/27/2001	336	350	0.33
#5710-SPK-4	7/27/2001	441	760	0.46
#5710-SPK-5	7/27/2001	315	200	0.28

WATER	DATE	LENGTH	WEIGHT	HG mg/l
Bradbury Pond				
BPN-SPK-1	6/26/2001	343	495	0.52
Cochran Pond				
CPN-SPK-1	7/10/2001	350	470	0.14
CPN-SPK-2	7/10/2001	382	600	0.16
CPN-SPK-3	7/10/2001	380	600	0.14
CPN-SPK-4	7/10/2001	381	605	0.14
Minnehonk Lake				
#5812-SPK-1	8/1/2001	335	350	0.31
#5812-SPK-2	8/1/2001	332	325	0.23
#5812-SPK-3	8/1/2001	340	350	0.24
#5812-SPK-4	8/1/2001	320	275	0.25
#5812-SPK-5	8/1/2001	353	350	0.30
Spectacle Pond				
#5410-SPK-1	8/7/2001	468	1120	0.31
#5410-SPK-2	8/7/2001	459	1120	0.43
#5410-SPK-3	8/7/2001	434	1120	0.19
#5410-SPK-4	8/7/2001	500	1580	0.58
#5410-SPK-5	8/7/2001	502	1490	0.49
Tufts Pond				
#28-SPK-1	6/28/2001	385	415	0.39
#28-SPK-2	6/28/2001	411	580	0.48
#28-SPK-3	6/28/2001	370	425	0.38
#28-SPK-4	6/28/2001	385	535	0.50
#28-SPK-5	6/28/2001	372	430	0.45
Sabattus Pond				
SPS-PKE-1	8/21/2001	558	1060	0.15
SPS-PKE-2	8/21/2001	505	730	0.09
SPS-PKE-3	8/21/2001	580	930	0.16
SPS-PKE-4	8/21/2001	525	830	0.11
SPS-PKE-5	8/21/2001	555	900	0.17

WATER	DATE	LENGTH	WEIGHT	HG mg/l
Androscoggin Lake				
#3336-PKL-1	2/7/2002	588	1380	0.64
#3336-PKL-2	2/7/2002	540	1050	1.04
#3336-PKL-3	2/7/2002	420	520	0.37
#3336-PKL-4	2/7/2002	552	1000	0.81
#3336-PKL-5	2/7/2002	500	840	0.68
Branch Pond				
#5754-PKL-1	2/6/2002	370	340	0.39
#5754-PKL-2	2/6/2002	350	290	0.27
#5754-PKL-3	2/6/2002	380	320	0.66
#5754-PKL-4	2/6/2002	335	230	0.26
#5754-PKL-5	2/6/2002	400	400	0.36
China Lake				
#5448-PKL-1	2/1/2002	552	880	0.73
#5448-PKL-2	2/1/2002	462	500	0.14
#5448-PKL-3	2/1/2002	565	1000	0.73
#5448-PKL-4	2/1/2002	550	1000	0.60
#5448-PKL-5	2/1/2002	580	1220	0.90
Givens Pond				
#5450-PKL-1	1/30/2002	330	210	0.39
#5450-PKL-2	1/30/2002	330	210	0.40
#5450-PKL-3	1/30/2002	327	230	0.23
#5450-PKL-4	1/30/2002	326	225	0.22
#5450-PKL-5	1/30/2002	380	340	0.46

Chain Pickerel. There are mercury data from only 8 lakes sampled for chain pickerel , which appear to be high in mercury, though standard deviations are low. More data are needed to get a better sense of the underlying distribution, but it is unclear whether new data would have much of an effect on the advisory. Chain pickerel were collected from 4 lakes during the winter ice fishing season 2002. Although there was considerable variation in concentrations among lakes, the mean concentration was the highest of all species sampled in 2001 (Table 2.2.1). Nevertheless, the mean concentration was lower than that for the 8 lakes sampled previously (0.92 ppm). Mercury concentrations appeared to be correlated with length for both these data and the historical data.

Confirming REMAP DDT analysis. From the 1993-94 REMAP study of Maine lakes, 15 lake/species samples were identified as having fish with elevated total DDT that exceeded Bureau of Health fish tissue action level (FTAL=64 ppb) in edible filets. Most of the REMAP data were flagged for some sort of quality assurance exceedance, so the data were questionable. To confirm the REMAP data, the lakes were resampled in 2000 and 2001. In 2000, a total of seven samples of fish were captured from a total of five lakes. In 2001, a total of six samples of fish were collected from a total of five lakes. Although we were unable to collect the same species as in the REMAP study in all lakes, we did capture related species, i.e. salmonids, from most lakes in 2000 and 2001. Total DDT concentrations from both 2000 and 2001 were much lower than those from the REMAP project (Table 2.2.2). None of the 2000 samples exceeded the FTAL.

Table 2.2.2. Total DDT in fish from some Maine lakes

SUMMARY

LAKE	MIDAS	LAKE CODE	SPECIES	N	DDX ppb
2000					
Eagle Lake	1634	LK1634	LKT	5	2.9
Eagle Lake					
Little Ossipee Pond	5024	LOW	LLS	5	3.0
Waterboro					
Lovewell Pond	3254	LPF	BNT	5	15.9
Fryeburg					
Lower Range Pond	3760	RPL	SMB	5	6.8
Poland		RPL	WHS	2	61.9
Round Pond	3818	LRP	BNT	5	4.1
Livermore		LRP	WHS	5	27.6
2001					
Cross L	1674	CRL	LLS	5	19.5
T17 R05 WELS					
Bradbury L	9763	BPN	SPK	1	11.7
New Limerick					
Cochrane L	1744	CPN	CPN	4	5.7
New Limerick					
Monson P	1821	MPM	LKT	5	3.3
Monson					
Upper Shin P	2202	USP	LLS	2	22.9
Mt Chase	2202	USP	BKT	1	25.0

RAW DATA

DEP ID#	DL	MPM-LKT-01	MPM-LKT-02	MPM-LKT-03	MPM-LKT-04	MPM-LKT-05
WRI ID #	ppb	01-316	01-317	01-318	01-319	01-320
EXT ID #	wet	1565	1566	1567	1568	1569
Compound						
2,4-DDE	1.0	<DL	<DL	<DL	<DL	<DL
4,4-DDE	1.0	5.87	1.24	0.52	0.96	1.55
2,4-DDD	1.0	<DL	<DL	<DL	<DL	<DL
4,4-DDD	1.0	0.40	<DL	<DL	0.40	0.44
2,4-DDT	1.0	1.28	0.84	1.00	1.04	0.88
4,4-DDT	1.0	<DL	<DL	<DL	<DL	<DL
Total DDX		7.55	2.08	1.52	2.40	2.87
TCMX (% rec.)	65-125	69.5	84.5	87.0	81.2	78.2
Sample weight (g)		25.04	25.01	25.00	24.98	25.13

DEP ID#	DL	BPN-SPK-01	CPN-SPK-02	CPN-SPK-03	CPN-SPK-04	CPN-SPK-05
WRI ID #	ppb	01-321	01-322	01-323	01-324	01-325
EXT ID #	wet	1570	1571	1572	1573	1574
Compound						
2,4-DDE	1.0	<DL	<DL	<DL	<DL	<DL
4,4-DDE	1.0	8.51	6.95	1.24	3.87	1.32
2,4-DDD	1.0	<DL	<DL	<DL	<DL	<DL
4,4-DDD	1.0	1.64	0.92	<DL	0.56	<DL
2,4-DDT	1.0	1.56	1.12	1.00	1.08	1.12
4,4-DDT	1.0	<DL	1.84	<DL	<DL	1.76
Total DDX		11.71	10.82	2.23	5.51	4.20
TCMX (% rec.)	65-125	71.0	115	90.0	113	96.5
Sample weight (g)		25.03	25.04	25.10	25.06	25.01

RAW DATA

DEP ID#	DL	CRL-LLS-01	CRL-LLS-02	CRL-LLS-03	CRL-LLS-04	CRL-LLS-05
WRI ID #	ppb	01-410	01-411	01-412	01-413	01-414
EXT ID #	wet	1575	1576	1577	1578	1580
Compound						
2,4-DDE	1.0	<DL	<DL	<DL	<DL	<DL
4,4-DDE	1.0	4.35	10.3	26.6	16.1	9.54
2,4-DDD	1.0	<DL	<DL	<DL	<DL	<DL
4,4-DDD	1.0	2.44	1.52	3.00	2.00	3.59
2,4-DDT	1.0	1.56	1.48	1.56	1.28	3.63
4,4-DDT	1.0	2.32	<DL	2.84	<DL	3.35
Total DDX		10.67	13.34	33.96	19.38	20.11
TCMX (% rec.	65-125	98.8	85.7	94.0	105	125
Sample weight (g)		25.03	25.04	25.03	25.02	25.06

DEP ID#	DL	USP-LLS-01	USP-LLS-02	USP-BKT-01
WRI ID #	ppb	01-420	01-421	01-422
EXT ID #	wet	1675	1584	1585
Compound				
2,4-DDE	1.0	<DL	13.25	<DL
4,4-DDE	1.0	6.79	7.15	1.56
2,4-DDD	1.0	<DL	<DL	<DL
4,4-DDD	1.0	3.47	2.24	<DL
2,4-DDT	1.0	1.24	3.59	0.88
4,4-DDT	1.0	3.35	4.67	<DL
Total DDX		14.86	30.90	2.44
TCMX (% rec.	65-125	103	82.6	75.8
Sample weight (g)		25.04	25.05	24.98

2.3

LOON EFFECTS STUDY

Assessing the impacts of methylmercury on piscivorous wildlife using a wildlife criterion value based on the Common Loon
(Report BRI2002-08)

2001 Final Report

Submitted to:

Maine Department of Environmental Protection
Surface Water Ambient Toxic Monitoring Program
State House Station 17
Augusta, Maine 04333

Submitted by:

David C. Evers, Oksana P. Lane, Chris De Sorbo, and Lucas Savoy
BioDiversity Research Institute[1]

19 April 2002

[1]Send correspondence to: BioDiversity Research Institute, 411 U.S. Route 1, Suite 1, Falmouth, Maine 04105 (207-781-3324) (david.evers@briloon.org)

Executive Summary:

Anthropogenic inputs of mercury (Hg) into the environment have significantly increased in the past few decades. In conjunction, the current availability of methylmercury (MeHg) in aquatic systems has increased to levels posing risks to human and ecological health. Risk levels vary considerably in response to MeHg availability, which is affected by lake hydrology, biogeochemistry, habitat, topography, and proximity to airborne sources. We selected the Common Loon as the most suitable bioindicator of aquatic Hg toxicity, based on ecological, logistical, and other criteria, including public valuations of natural resources. Opportunistic and probability-based sampling efforts from 1994-2001 indicate New England's breeding loon population is at unacceptable levels of risk to Hg contamination, particularly in Maine. Based on risk categories developed from the literature and *in situ* studies by BioDiversity Research Institute and their collaborators, at least 26% of the breeding loon population in Maine is estimated to be at risk, while at least 19% of the eggs laid are potentially impacted.

Because results from national sampling indicated loons were at most risk from Hg in New England (particularly Maine), we identified several individual- and population-level parameters to better understand the extent of mercury toxicity across Maine. Between 1994-01 we collected 199 abandoned eggs (60 in 2001) as well as blood and feather samples from 303 adult (50 in 2001) and 103 juvenile loons captured in Maine. The Hg concentrations in these samples were used to relate sublethal impacts on behavior, developmental stability, immunosuppression, individual survival, egg development, and overall reproductive success. In the Rangeley Lakes Study Area, a total of 181 loon territories were monitored on 44 lakes during 1998-01. Current monitoring efforts and historical data comprise 674 territory-years measured. Behavioral observations were conducted for over 1,500 hours on 16 lakes with 38 loon territories from 1998 to 2000.

Several reproductive measures significantly declined for loon pairs at high risk to prey MeHg availability, thereby corroborating studies in high-risk sites in Nova Scotia and Wisconsin that show Hg impacts reproductive success. Based on 219 loon territories representing 946 territory-years surveyed we found that pairs above the lowest observed adverse effect level (i.e., >3.0 ppm in the blood) fledged 40% fewer young than pairs below our no observed adverse effect level (i.e., <1.0 ppm in the blood). We also found similar significant patterns of lower productivity for other reproductive measures. We view the implication of long-term declines in these reproductive measures as serious and contend they would not be detected by traditional survey techniques.

Insight into why loons are facing Hg-based population declines can be viewed through our hazard assessment process that is based on a weight-of-evidence approach. Physiological impacts of Hg are measured through two key biomarkers: corticosterone stress hormone levels and flight feather asymmetry. Circulating corticosterone hormone levels are strongly linked with increasing blood Hg levels and are not related to capture and handling stress. Corticosterone hormone levels increase on an average of 14.6% for every one ppm of increase in blood Hg levels (n=239). This indicates that loons with high blood Hg levels have higher rates of chronic stress and may therefore have compromised immune systems. Asymmetry measurements provide insights into developmental stability and potentially reproductive fitness. Three years of flight feather measurements have shown agreement among years that loon breeding populations with greater exposure to Hg have significantly greater asymmetry than populations at low risk (n=227). Greater asymmetry may indicate disruptions from stressors on their embryonic development and current physiological status as well as a potential decline in reproductive fitness.

Many behavioral impacts that appear to be related to the neurotoxic effects of MeHg can rarely be observed in the field. We found adult loons in high risk situations left eggs unattended 14% of the time, compared to 1% in controls. Several cases of direct field observations indicate that adult loons with high MeHg body burdens avoid incubating their eggs and display atypical behaviors such as patrolling in front of, or sitting next to the nest. We documented a significant negative relationship between adult blood Hg and foraging behavior, and a significant positive relationship between adult blood Hg and brooding behavior. Recategorizing our data according to energy demands revealed a significant inverse relationship between blood Hg and time spent in high energy behaviors. Our findings are consistent with other studies linking Hg and lethargy, reduced motivation to hunt prey, and compromised foraging abilities.

Current levels of Hg in Maine's lacustrine ecosystems also appear to be impacting individual survival of adult and juvenile loons. Recaptured adult loons exhibit a significant annual increase of Hg (9% in males, 5.6% in females) that we predict will significantly reduce lifetime individual performance. A model of this impact indicates a decline of 13 to 8 young produced over a loon's lifetime. Further, juveniles from high-risk territories have increasing blood Hg levels of 3% per day during the summer, potentially reaching dangerous levels after the final feather molt at 11 weeks of age.

Characterization of the risk imposed by MeHg bioavailability in aquatic systems to high trophic level obligate piscivores such as the Common Loon indicates negative population level impacts in Maine. Although the impacts of Hg on loons are varied, complex, and not yet fully understood, the combination of high exposure to a significant part of the breeding population and the "bottom-line" impact of reducing overall reproductive success to 40%, is creating an aquatic landscape that is not sustainable for the Common Loon in Maine.

Current models indicate a negative population growth rate. Because of the loon's life history strategy (i.e., long lived, slow maturing, and low fecundity) the annual and continual impacts of this type of stressor causes an erosion of the non-breeding or buffer population that serves as a natural cushion to catastrophic events. Once this buffer population is exhausted, the occupancy of established territories will shrink and it will be more obvious that loon populations are declining. However, the realization of shrinking loon populations at that stage will require drastic and potentially expensive efforts to reverse the decline. Models based on a 25-year, statewide comprehensive monitoring effort in New Hampshire show approximately half of Maine's buffer population has been exhausted. Certain areas in Maine, such as the Allagash area that may be particularly impacted from Hg, may already exhibit exhaustion of the buffer population and a shrinking number of territorial pairs.

Continued refinement of model parameters and either a probability-based sampling scheme or new sampling efforts in northern Maine will provide higher confidence in our estimates that will therefore assist in state-based policy efforts as well as national regulations that reflect the ecological injury Hg is currently having on the freshwater landscape.

Our approach to a high resolution risk characterization for the Common Loon provides the necessary information for developing a Maine-based wildlife criterion value (WCV). Recent efforts by the USEPA have established a generic WCV with several major limitations that we are improving with this study. A WCV estimates wildlife population viability through measurement of contaminant stressors such as surface water Hg concentrations.

First-year measurements of exposure parameters indicate a bioaccumulation factor (BAF) of 75,000 for trophic level 3 and 120,000 for trophic level 4 based on the relationship of total Hg in unfiltered water with total Hg in yellow perch. We are not able to calculate a Maine-based reference dose because of several outstanding uncertainties. Further work will correct this limitation and a Maine-based WCV that is protective of aquatic piscivorous wildlife will be obtainable.

The full report is available as a separate file with the 2001 SWAT report at http://www.state.me.us/dep/blwq/monitoring.htm

2.4

PREDICTING MERCURY LEVELS IN FISH

PREDICTION OF THE CONCENTRATION OF MERCURY IN FRESHWATER FISH IN MAINE

Aria Amirbahman, Assistant Professor of Civil and Environmental Engineering, University of Maine, Orono, ME 04469.

Introduction:

The objective of this research is to predict the concentration of mercury (Hg) in freshwater fish from Maine lakes based on the background aqueous phase chemistry. A methylmercury (MeHg) chemical speciation model developed by us previously will be used to correlate the fish Hg concentration to the speciation of MeHg with respect to chloride and the dissolved organic carbon (DOC).

Considerable effort was spent in August 2002 on designing sampling schemes and selecting lakes that would best serve the study objectives. The following 5 lakes were selected based on the existing fish Hg data provided by the Maine DEP.

Lake	Fish Hg concentration (ppb)	
East Musquash	0.63	Topsfiled area
Matagamon	0.53	Piscataquis County
Great Pond	0.38	Belgrade area
Auburn	0.15	Poland area
Sabbatus Pond	0.06	Lewiston area

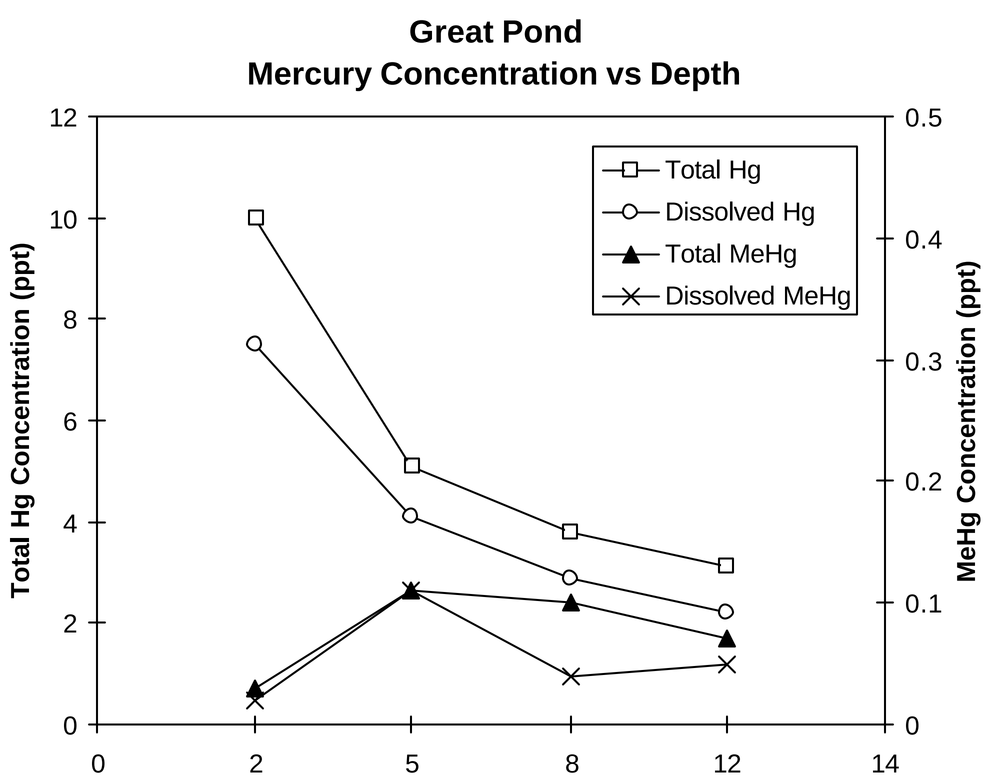
Preliminary Results:

Water samples were taken at Great Pond on 5 October 2001 and analyzed for Hg and MeHg. A Teflon kemmerer was used to collect water samples. Samples were kept in the dark in a cooler until they were transferred to the lab where they were refrigerated prior to the analysis. Sample analysis was performed according to the EPA method 1631. Hg and MeHg were analyzed in both filtered (dissolved defined as passing through 0.45 μm filter) and unfiltered (dissolved + particulate) samples. The results are shown below in the attached figure.

The results in the attached figure show higher total and dissolved Hg concentrations at higher depths, perhaps indicating atmospheric deposition as the main source of Hg input in Great Pond. The results for MeHg are not conclusive, as they do not show a clear trend in MeHg distribution with respect to the depth.

Sampling of all five lakes were planned starting in mid May 2002, after the spring turnover and just before the onset of summer stratification. The plan consisted of sampling the deepest part of the lakes 4 times during the summer and fall. The sampling would span the period just before the early summer stratification, and just after the fall turnover.

We began sampling the 2002 sampling campaign on 16 May 2002 at East Musquash Lake. Unfortunately, during the sampling, the Teflon kemmerer was lost due to a snapped cable. On June 5th, Mr. Dan Placzek, a professional diver, conducted an eight hour search of the lakebed, but was unable to find the kemmerer. We then ordered a kemmerer through Wildco Products, and received one toward the end of August. It was decided at that stage to postpone sampling until the 2003 season, in order to collect a complete set of Hg and MeHg data before and after the summer stratification. Sampling will resume in mid May 2003 and finish by the end of September 2003.



2.5

LEA MERCURY STUDY

The Lakes Environmental Association (LEA) is a private, non-profit organization founded in Naples, Maine in 1970 to protect the water quality and watersheds of the Sebago-Long Lake Region. The Association serves the towns of Bridgton, Denmark, Harrison, Naples, Sweden, and Waterford as well as Sebago Lake. LEA wished to monitor mercury in fish from lakes within these towns and collected 23 samples of fish from 4 area lakes and ponds. DEP is interested in partnering with groups that can assist monitoring of a number of lakes and ponds. DEP agreed to share costs equally for those samples that met DEP protocols. A total of 4 samples of at least 4 fish each from a total of two lakes met DEP's requirements. The results show that concentrations of mercury in samples of brown trout, largemouth bass and smallmouth bass from Highland lake exceeded the Maine Bureau of Health's Fish Tissue Action Level (FTAL=0.2 mg/kg) but concentrations in white perch did not (Table 2.4.1). Concentrations of mercury in largemouth bass from Keoka Lake also exceeded the FTAL. These concentrations are somewhat lower than the statewide averages for these species. Concentrations in fish from Long Lake and Moose Pond also exceeded the FTAL, but sample sizes are too small to make these data definitive.

Table 2.4.1. Mercury concentrations in LEA lakes, 2001

SUMMARY

WATER	MIDAS NO.	TOWN	SPECIES CODE	HG mg/l	N
HIGHLAND L	3454	Bridgton	BNT	0.24	4
			LMB	0.23	5
			SMB	0.35	4
			WHP	0.10	5
LONG L	5780	Bridgton	SMB	0.35	1
MOOSE P	3134	Bridgton	SMB	0.27	1
			WHP	0.57	2
KEOKA L	3416.0000	Waterford	LMB	0.40	5

LEA Fish/Mercury data:

Lake/ Midas	Date	Species	Sample ID	Length mm	Result (mg/kg)
Highland 3454	8/14/2001	Brown Trout A	BTHI A	330	0.0325
Highland 3454	8/15/2001	Brown Trout B	BTHI B	356	0.1691
Highland 3454	8/15/2001	Brown Trout C	BTHI C	381	0.3306
Highland 3454	8/14/2001	Brown Trout D	BTHI D	406	0.4190
Highland 3454	8/10/2001	Small Mouth A	SMHI A	229	0.1414
Highland 3454	8/14/2001	Small Mouth B	SMHI B	330	0.4079
Highland 3454	8/19/2001	Small Mouth C	SMHI C	356	0.4085
Highland 3454	8/19/2001	Small Mouth D	SMHI D	381	0.4564
		Small Mouth D dup.	SMHI D dup		0.4610
		W. P. Composite	WPHI		0.1003
		W. P. Composite dup.	WPHI dup		0.0984
Highland 3454	8/10/2001	White Perch A	WPHI A		
Highland 3454	8/10/2001	White Perch B	WPHI B		
Highland 3454	8/10/2001	White Perch C	WPHI C		
Highland 3454	8/10/2001	White Perch D	WPHI D		
Highland 3454	8/10/2001	White Perch E	WPHI E		
Long 5780	8/18/2001	Small Mouth	SMLL	305	0.3517
Moose 3134	8/19/2001	Small Mouth	SMMO	254	0.2678
Keoka 3416	8/3/2001	Large Mouth A	LMKO A	305	0.1584
Keoka 3416	7/28/2001	Large Mouth B	LMKO B	305	0.2436
Keoka 3416	8/3/2001	Large Mouth C	LMKO C	330	0.3380
Keoka 3416	7/26/2001	Large Mouth D	LMKO D	381	0.4900
Keoka 3416	8/3/2001	Large Mouth E	LMKO E	381	0.7598
Highland 3454	8/10/2001	Large Mouth A	LMHI A	254	0.1951
Highland 3454	8/10/2001	Large Mouth B	LMHI B	279	0.2356
Highland 3454	8/10/2001	Large Mouth C	LMHI C	292	0.1784
Highland 3454	8/10/2001	Large Mouth D	LMHI D	305	0.2706
Highland 3454	8/10/2001	Large Mouth E	LMHI E	318	0.2806
Moose 3134	8/7/2001	White Perch A	WMPO A	279	0.4299
		White Perch A dup.	WMPO A dup		0.4159
Moose 3134	8/7/2001	White Perch B	WMPO B	305	0.7236
SRM was dogfish m		**% recovery**	**SRM**		
		104	DORM A		
		102	DORM B		**LEA**
		102	DORM C	**Fish Species**	**Average for Group**
				Brown Trout HI	0.23
		% difference	**Duplicates**	Small Mouth HI	0.35
		1.00	SMHI D	White Perch HI	0.1
		1.90	WPHI	mall Mouth Lor	0.35
		3.20	WMPO A	Small Mouth MO	0.27
				Large Mouth KO	0.4
		% recovery	**Spikes**	Large Mouth H	0.23
		86	SMHI D	White Perch MO	0.58
		85	WPHI		
		92	WMPO A		